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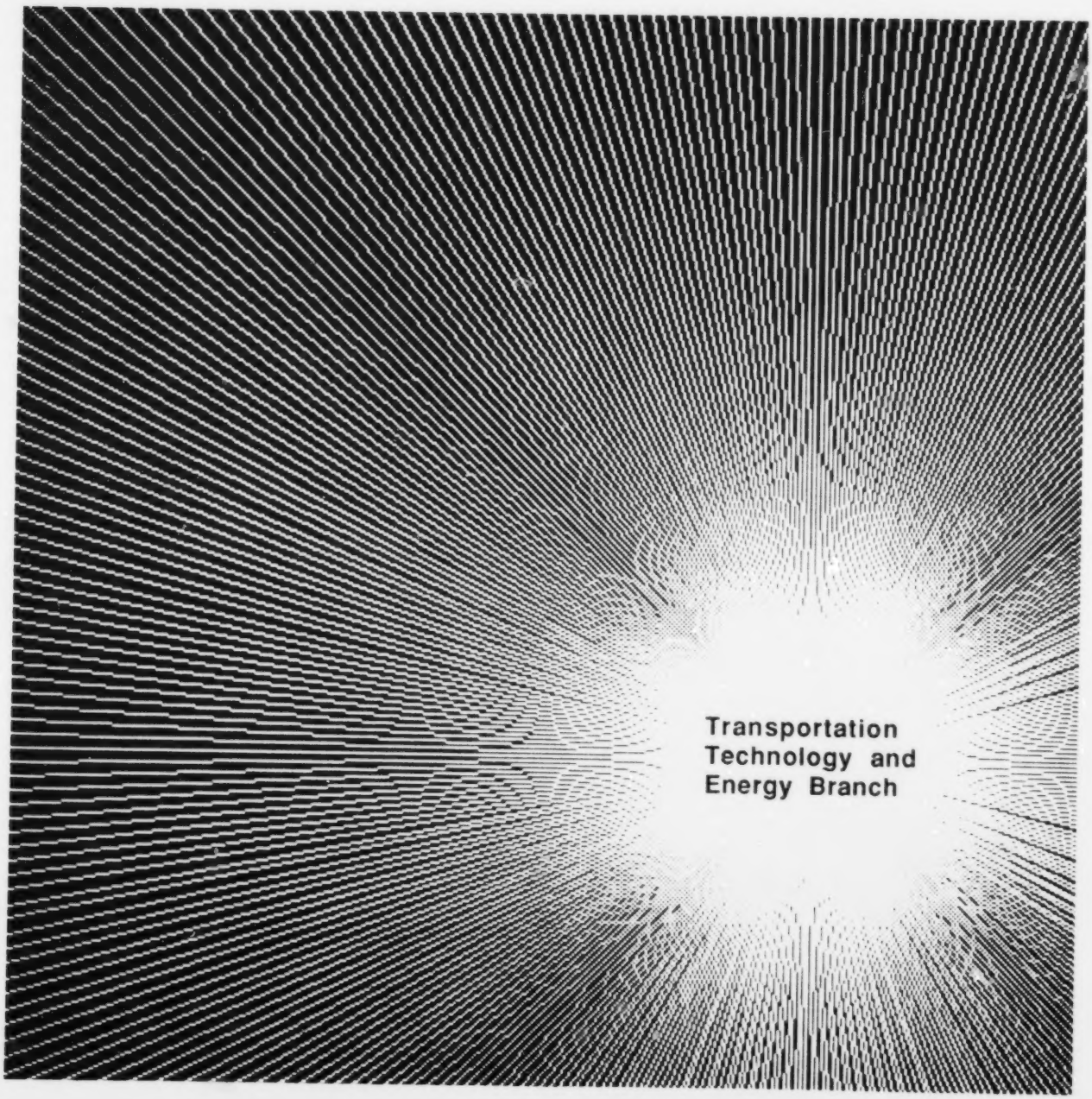

Wide Area Vehicle Monitoring (WAVM) System Development in Ontario and the Emerging Worldwide Competition

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J. Tsai
Transportation Control Technology and Systems Office

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For additional copies, write:
Transportation Technology and Energy Branch
Room 321, Central Building
1201 Wilson Avenue
Downsview, Ontario
Canada M3M 1J8
(416) 235-3466

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ABSTRACT

The Wide Area Vehicle Monitoring (WAVM) system is an application of satellite communications and navigation technologies. The system will provide real-time truck location and identification information, and two-way message communication services between equipped trucks and trucking company base stations. Many trucking companies consider the WAVM system an important missing link between their computerized fleet dispatch system and their trucks on the road. Application of WAVM technology will bring about a major improvement in truck dispatching and management philosophy.

Since the project's initiation, Ontario's WAVM system has been enthusiastically received by the trucking industry. Coordinated and assisted by the Ontario Ministry of Transportation (MTO), Telesat Canada and two Ontario trucking companies have undertaken a project to implement an interim WAVM system based on the existing INMARSAT satellite channels. This system is called the Interim Mobile Data System (IMDS) and is being developed by Ontario's high technology industry. IMDS commercial services are expected in 1990. Meanwhile, the emerging WAVM market opportunities have also attracted the attention and interest of many advanced industrial countries. This presentation will describe WAVM development and application in Ontario, and review the emerging worldwide competition in the WAVM technology and market.

WAVM PROJECT BACKGROUND

Trucking Industry Needs

In long-haul and regional trucking operations, two traditional problems trucking companies face are the inability to locate a truck when required and to contact the driver when needed. These problems exist because truck fleet operations cover a very wide geographical area and there is a lack of suitable vehicle position and communications technologies to serve the needs of the trucking industry. Introduction of the just-in-time transportation service and the wide area irregular route truckload service have increased the complexity of these problems as well as the urgency to have them solved.

More specifically, the use of just-in-time inventory systems by the industry has turned a carrier's fleet on the highway or railway into a conveyer belt for the shippers and the manufacturers. The just-in-time transportation service has placed a critical demand on the timing of goods delivery from origin to destination. In some cases, a 15-minute window is demanded by the manufacturers or the shippers. For the just-in-time system to work properly, shippers have to track the movement of their goods regularly. This demand has prompted carriers to computerize and to operate their fleet management and dispatch systems in real time as much as possible.

Deregulation has also created a new breed of trucking company that offers irregular route truckload service for intercity shipments. Under deregulation, the carriers, armed with the knowledge of where their trucks are likely to be, can match drivers, tractors, trailers, and shippers to maximize the use of their equipment. This new wave of trucking operations has created the demand that carriers locate their trucks as required and reach their drivers as needed.

When a trucking company has hundreds or thousands of tractors and trailers, and operates in a wide geographic area, the need to keep track of the trucks and coordinate overall fleet operation in real time becomes an urgent and complex issue. Effective coordination of the just-in-time transportation service and other wide area trucking operations so that each truck and every driver is efficiently used to serve each customer's shipping demands will require knowledge of the truck location and the ability to reach the driver when needed in real time.

Wide Area Vehicle Monitoring (WAVM) System

The WAVM system is an application of satellite communications and navigation technologies. The system will provide real-time truck location and identification information, and two-way message communications services between the equipped trucks and the trucking company base station. Utilizing the communications infrastructure provided by the Mobile Satellite (MSAT), and the vehicle positioning capability

provided by the Loran-C land-based vehicle navigation system (or by navigation satellites within the Global Position System, GPS), the WAVM system (Figure 1) will be capable of operating from coast to coast in North America. Many trucking companies consider the WAVM system an important missing link between their computerized fleet dispatch system and their trucks on the road (Figure 2). Application of WAVM technology will bring about a major change and improvement in truck dispatching and management philosophy.

WAVM Project

Recognizing the potential of WAVM system technology and working in cooperation with the trucking industry and the high technology industry, in 1985 the Ministry of Transportation of Ontario (MTO) organized a WAVM project committee to facilitate this system's application to the trucking industry and to promote this new transportation market opportunity to the high technology industry [1]. The current members of the project committee include:

- Telesat Canada (Telesat Mobile Inc.)
- Thompson Transport
- Frederick Transport
- Department of Communications (Federal)
- Ministry of Transportation of Ontario

Telesat Canada is a private commercial company, originally established as a Canadian corporation by an Act of Parliament and authorized to install and operate commercial satellite communication systems throughout Canada. Telesat has recently created a new company, Telesat Mobile Inc. (TMI), to carry out the mission of providing domestic mobile satellite communications. TMI is owned 50 percent by Telesat Canada, 30 percent by CP Ltd. and 20 percent by C. Itoh & Co. Ltd.

Frederick Transport of Dundas, Ontario is one of Canada's largest truckload carriers specializing in long-haul irregular route truckload service and international transportation between Canada and the United States. Frederick Transport is a recognized industry leader in the development and application of sophisticated computerized fleet dispatch systems.

Thompson Transport of St. Thomas, Ontario is a major just-in-time carrier. The company's various services continue to demonstrate that mobile communications is a top priority in the evolution of just-in-time transport. Thompson Transport provides service to all major automotive manufacturers and is expanding rapidly in the U.S. trucking market.

Once in use, WAVM will increase the competitiveness and efficiency of Ontario's trucking industry and will support the development of a new Canadian high technology

industry to serve the emerging WAVM market. In addition, mobile satellite products and services are anticipated to be a high growth industry during the 1990s in both domestic and international markets.

WAVM DEVELOPMENT AND APPLICATION IN ONTARIO

Since its inception, the WAVM project committee has evaluated various vehicle positioning and communications technologies for possible WAVM application and has defined the WAVM system operating requirements based on the participating trucking companies' needs and requirements. These system requirements have been incorporated into the MSAT service design by the Department of Communications and Telesat Canada [2]. Between now and the time when MSAT service will be available (1993), a WAVM system (Figure 3) based on the existing INMARSAT satellite channels is being planned and developed by WAVM committee member, Telesat Mobile Inc. in collaboration with Frederick Transport and Thompson Transport, to provide interim services [3] to the transportation industry. This system is called the Mobile Satellite Fleet Management System and is compatible with the future MSAT service [4] which will be expanded to include two-way voice communications.

Mobile Satellite Fleet Management System – Telesat Mobile Inc.

The Mobile Satellite Fleet Management System uses an existing geosynchronous satellite – INMARSAT's MARECS B located at a longitude of 26 degrees west to provide two-way message communications links between dispatchers at the trucking company's base station and trucks on the highway. It also uses an existing navigational system such as Loran-C to provide vehicle location data. In addition to reporting vehicle identification and location, the system will provide two-way digital code messaging, two-way general text messaging, and text transfer.

The MARECS B satellite's footprint coverage is in areas east of the Manitoba-Ontario border and eastern United States. This coverage will be expanded in 1990 to the whole North American continent as shown in Figure 4. Vehicle positioning coverage is affected by the Loran-C network. Currently, the accuracy of the position data for vehicles travelling in the eastern continental U.S.A. and on the Trans-Canada Highway from the Atlantic provinces to Kenora in western Ontario and in southern Ontario would range from 100 to 200 m. An accuracy of 400 m can be obtained in the central part of North America including south-east Manitoba, northern Ontario and central Quebec. In general, position accuracy of 1 km is considered adequate for the long-haul trucking operation.

Hub Station to Mobile

As shown in Figure 5, the system has one radio frequency channel with a bandwidth of 5 KHz in the forward direction from the satelite Hub station to a vehicle. This forward link is made up of one C-band channel (6.42 GHz) from the central Hub station to the

satellite, and one L-band channel (1.54 GHz) from the satellite to the vehicle on the highway. The link between a dispatch centre and the satellite Hub station can be a land line or VSAT link. This forward direction channel from the Hub station to vehicle is time-shared by all the end-users, transportation dispatch centres, in the system. The incoming data packets from the transportation dispatch centres are processed, compressed into bursts and scrambled if necessary in the Hub messaging facility.

After modulation, the composite signal is broadcasted from the Hub station via the satellite at a transmission speed of 1200 bits per second to every vehicle registered with the system. However, only those vehicles with proper identity codes will be able to receive the message. Each vehicle will receive its information from the dispatch centre every 15, 30, or 60 minutes. The information content of an incoming data packet from the transportation dispatch centre includes the dispatcher's identity code and pre-programmed message codes. The dispatcher can also compose the message using a keyboard and send it to a selected vehicle or broadcast it to the fleet. This is referred to as general messaging and the message length can range from 32 to 128 characters.

Mobile to Hub Station

To complement this forward direction channel, there are six reverse channels for the transmission of information from the vehicles on the highway to the transportation dispatch centres. Each of these channels consists of one L-band (1.64 GHz) channel from the vehicle to the satellite, and one C-band (4.26 GHz) channel from the satellite to the Hub station. The same land line or VSAT link can be used between the dispatch centre and the Hub station. These reverse direction channels are time-shared by the vehicles on the highway. Each reverse direction channel will have a capacity of 4000 reports per hour. The system has the capacity to accommodate 6000 vehicles. If additional satellite channels are used, more vehicles can be accommodated.

The vehicle on-board unit can automatically send its pre-packaged information at a transmission speed of 600 or 1200 bits per second to its dispatcher at the transportation dispatch centre. This information includes the vehicle identification number, current vehicle location data and a pre-programmed message code. Every vehicle that has registered with the system can send the information to its dispatch centre every 15, 30 or 60 minutes. The vehicle on-board unit will include a driver keyboard and display unit and the Loran-C receiver to provide vehicle location data. It also has electronic interfaces available to connect vehicle status monitoring devices. In the future, Global Positioning System receivers could be used to provide wide area positioning coverage for other transportation sectors such as air, marine or rail.

When there is a need to transmit special text messages to a dispatcher, a vehicle driver can use the keyboard to compose the message and transmit it through one of the reverse channels assigned to handle this demand general messaging. An estimated 330 messages per hour with an average length of 32 characters can be accommodated on one channel.

System Features

In addition to the previously mentioned basic features of periodic update of vehicle identification and location, two-way pre-programmed messaging and two-way general messaging, the system will have other value-added features such as an electronic mail box, facsimile (text transfer), and electronic data interchange. These features will allow a dispatcher to send permits to a driver at the border crossing point, and a driver to leave a message for the dispatcher or his or her family. Transportation companies can send bills of lading and invoices electronically to enhance cash management processes.

For transportation companies who use a dispatch computer, the system can provide error-corrected real-time data including vehicle position (latitude and longitude) and other dispatch information. The dispatchers can access all information and messages in the database established in their computerized dispatch system through an interchange of information with the satellite Hub station.

For transportation companies who use manual dispatch, the system can also provide additional processed data such as truckload status including load number, driver number, tractor number, trailer number, load origination and destination, last dispatch and current locations, speed and other vehicle status information. In this case, a dispatcher requires only a personal computer to retrieve information from the satellite Hub station.

Economic Benefits of the WAVM Project

With these very useful features, transportation companies will be able to know the locations of every vehicle, to reach their drivers when needed, and to track every load in transport. The system will allow trucking companies to react quickly to a shipper's call and will make it easy to match cargo to a truck and a truck to a driver. This will enhance their equipment and human resources utilization, increase the loaded miles and improve their customer service in just-in-time transport and irregular route truckload transport. The system will also cut transit times because drivers (or owner/ operators) will not have to stop for check-in calls and waste road time. Because of the on-line load tracking capability, shippers can be alerted to any delays in advance and alternative arrangements can be organized to alleviate the delays. The overall result will be improved efficiency and profitability in the trucking industry. For shippers, the system will reduce shipment tracing costs, enhance just-in-time coordination and help them act on emergency situations in a timely manner.

Since drivers are paid on a per-mile basis, the system also serves the interests of drivers and owner/operators. The system can automatically do the check-in calls and reduce the number of times a driver has to stop on the road, increasing the driver's efficiency. The system can also make driving safer by alerting drivers to poor road conditions or hazardous weather ahead. It can be used to monitor dangerous goods

and provide an emergency calling feature to get needed assistance as soon as possible. In general, the system is seen as a key survival tool for trucking companies in the present-day competitive deregulated transportation environment. From this perspective, the system becomes a tool for preserving and creating jobs in the trucking industry.

The development of this Mobile Satellite Fleet Management System will provide Telesat and Ontario manufacturers with a solid foundation and a leading edge in the competitive mobile satellite technology and service market. In order to gain some understanding of these direct economic benefits, MTO commissioned a study on the economic impacts of the WAVM project [5]. This study is based on the data proposed by the potential equipment suppliers and the service provider. WAVM development and implementation involves both a development phase and a commercialization phase. Estimated spending in the development phase is $15 million over a two-year period, while spending in the commercialization phase is estimated to be $49 million over a five-year period. The study results, premised on a high degree of Ontario manufacturing content, suggest a very substantial contribution to Ontario's economy. These include a GDP value of approximately $110 million and about 2100 person-years of employment.

Funding and Development of the Mobile Satellite Fleet Management System

The Mobile Satellite Fleet Management System formed the basis for a research and development funding request to the Ontario Premier's Council Technology Fund. This fund was established in 1986 by the Ontario government to support science and technology research in the private sector and post-secondary educational institutions.

Coordinated and assisted by MTO, an application was made, in 1988, to the Ontario Premier's Council Technology Fund by WAVM committee members, Telesat Canada (Telesat Mobile Inc.), Thompson Transport, and Frederick Transport for financial support in meeting the project's estimated research and development cost of $9.7 million.

Following a positive decision by the Premier's Council Scientific Advisory Panel, Telesat Canada (Telesat Mobile Inc.), Thompson Transport, and Frederick Transport were awarded in January 1989, by the Ontario government $4.85 million which is 50 percent of the total cost to research and develop the system and service.

The project will consist of research and development to produce a satellite-based fleet management system for transportation industry applications. The work will lead to the development and production of advanced on-board terminals, the associated antennas and sub-systems for vehicle positioning and communicating directly with the transportation dispatch centres via satellite. The on-board terminal will be designed for use initially on vehicles, and eventualiy on ships or aircraft. The satellite Hub station will also be designed, produced, and installed to support network communications

protocols and specialized message handling facilities. The system will eventually operate on Canada's own MSAT satellite which will be launched in 1993. Until then, arrangements have been made for the use of the INMARSAT MARECS B satellite. Telesat Mobile Inc. is working with Canadian Astronautics Limited, Gandalf Technologies Inc. (Ontario manufacturers) and Hughes Network Systems to design and manufacture the Hub station and on-board terminal equipment to support the Mobile Satellite Fleet Management System services. Frederick Transport and Thompson Transport will participate in the testing and evaluation of the truck on-board terminals and fleet management system. The Canadian federal government has also ordered 300 on-board terminals for tests and demonstrations. The commercial services are expected in 1990.

ADVANCED WAVM APPLICATION RESEARCH

With the imminent implementation of the WAVM system, the age-old trucking industry problems of inability to locate trucks and communicate with drivers when needed will be resolved in the very near future. The participating trucking companies are in the process of integrating this technology into their operational structure to ensure successful application of the vehicle positioning information and two-way communications facilities provided by the WAVM system.

There are broader implications and applications of the WAVM technology. Further research is needed in exploring the potential transportation innovation opportunities provided by the WAVM technology.

Transportation Management Innovation Application

With the WAVM system currently being developed, the trucking industry will be able to effectively and efficiently manage its fleets. However, the industry still cannot optimally respond to the sometimes adverse highway environment due to the lack of real-time information on recurring and non-recurring highway congestion caused by variables such as vehicle accidents, traffic demand over roadway capacity, and severe weather conditions.

Just-in-time highway environment information would allow trucking companies to respond to adverse highway conditions in real-time by activating a back-up transportation plan for fleet dispatching, routing and management and, in this way, ensure the provision of satisfactory service [6]. For example, any information on adverse highway conditions provided by the WAVM system will allow trucks to adapt to highway conditions, thereby increasing truck fleet productivity and improving highway efficiency.

However, highway-related information is currently collected by different agencies at different levels of detail and at different intervals. There has been little or no effort to integrate and utilize the information efficiently for the benefit of the trucking industry

even at local or regional levels. To complicate the issue further, for long-haul trucking industry application, the highway environment information must be provided on a continental basis. This may imply that a trucking company will have to interface with many regional highway information centres or agencies.

Thus, in order to transform the WAVM technology from a tool of managing the trucking fleet into a tool of managing the sometimes adverse highway environment where trucks operate, research is needed to develop a modern highway information system. This system must contain real-time or near real-time highway environment related information including traffic congestion status, travel time, dynamic roadway capacity, border crossing delays, weather conditions and appropriate alternative routes to the congested highway section.

Because the highway environment related information is spatially based, the geographic information system technology may be used to facilitate the development and maintenance of the system. Because this highway information system may be accessed by various transportation companies located in Canada and the U.S.A., a universal interface and information access method such as electronic data interchange (EDI) may be used to facilitate the system's widespread applications and the access by a WAVM system utilized by the trucking industry.

Furthermore, the proposed highway information system can be a continent-wide system or consist of many regionally based sub-systems. The system can utilize a dedicated satellite channel to distribute the information. The trucking company dispatch centre can access the information for the whole fleet, then distribute the relevant information via a WAVM system to each individual vehicle and driver.

The system can also be designed to provide the information directly to the vehicle. This system may also be utilized by tourists and recreational travellers to obtain scenic and recreational driving information. Another potential application is to adapt the vehicle on-board unit to have the capability to assist transportation companies in observing drivers' hours of work regulations and to ensure the safe operation of the vehicle on the highway.

Multimodal Transportation Applications

The potential of transport vehicle monitoring, communications and control extend beyond the highway sector. There are potential air transportation applications in northern and southern Ontario. An example is reducing air traffic congestion at busy southern Ontario airports. There are also potential applications of the WAVM technology in Great Lake marine transportation including pleasure craft navigation, communications and safe operation. The potential application of the WAVM technology in intercity bus vehicle location monitoring and passenger communications is also very promising. The recent hijacking of an intercity bus from Montreal to Ottawa (1989) also

demonstrates the need for using WAVM technology to enhance the passenger safety feature.

THE EMERGING WORLDWIDE COMPETITION IN WAVM

These emerging WAVM market opportunities have also attracted the attention and interest of many advanced industrial countries. For example, the U.S.A., several European countries and Japan all have WAVM-type programs or systems in various stages of development.

Development in the U.S.A.

There are many WAVM-type systems currently being developed by various suppliers [7], such as American Mobile Satellite Consortium (AMSC), Geostar Corp., Qual-Comm Inc., Transtrack Inc. and Railstar Control Technology in the U.S.A. AMSC consists of seven American companies. It has evolved from the original twelve applicants who applied to the U.S. Federal Communications Commission (FCC) to provide mobile satellite services in the U.S.A. AMSC and the Canadian company TMI have agreed to jointly launch and operate MSAT satellites and ground stations. They have collaborated to define common characteristics of a mobile satellite system for North America and to define standards of the mobile voice terminal. This mutual effort will allow TMI and AMSC to provide satellite coverage over the North American continent and back each other up in satellite operation. AMSC could launch its satellite in 1994 and TMI plans to launch its satellite in 1993.

Geostar's system, called radio determination satellite service (RDSS), currently utilizes leased satellites, GTE's GStar III, in a geostationary orbit. It uses mobile transceivers to periodically transmit information including vehicle location provided by a Loran-C receiver to the satellite. The satellite then beams the information to Geostar's system control centre which sends the vehicle information over packet switched networks to the end-users, i.e. transportation dispatch centres. Currently, the system provides only one-way data service from the vehicle to the dispatch centre. Geostar plans to have two-way service in 1990. The new system, called Satellite System 2C, allows truckers to both send and receive data from their dispatcher's office. Geostar also plans to launch its own satellites within the next three to five years. Frederick Transport and United Van Lines Inc. use the Geostar system in order to be more responsive to customer service requests.

QualComm's system uses leased satellite channels on GTE Spacenet's GStar I satellite to provide two-way mobile messaging communications and a vehicle position reporting service. This service operates in the Ku-band (11 GHz – 14 GHZ), used primarily for fixed applications for voice, data and video. QualComm's on-board Omnitracs terminal comprises a communications transceiver, a display, a keyboard, a mechanically steerable tracking antenna and a Loran-C receiver. The system polls each mobile unit several times a minute. When a truck's unit is turned on, it

acknowledges the poll and receives any messages from the dispatcher. The QualComm system has to constantly turn its directional antenna to track the satellite. As a result, the antenna's moving parts are prone to failure. Operating in Ku-band frequencies, the QualComm system is also susceptible to problems created by weather such as heavy rainfall, dense fog, heavy snowfall or cloud. On the other hand, TMI's Mobile Satellite Fleet Management System uses omni-directional antennas and operates in L-band frequencies which can transmit more reliably in bad weather. It is reported that Schneider National Inc. plans to outfit its entire fleet with some 5000 Omnitracs terminals.

In another development, Railstar Control Technology [8] has tested and demonstrated its satellite-based communications and train management system. Railstar has space on the GTE Spacenet III/Geostar RO1 satellite and the GTE GStar III/Geostar RO2 satellite. In Railstar's system, the train on-board unit can transmit train location, speed, direction, and other parameters via an omni-directional antenna and satellite link to Railstar's computer centre. In the future, a two-way communications capability will enable dispatchers to send messages to train crews.

Instead of relying on geosynchronous satellites, Transtrack utilizes meteor-burst technique to provide two-way mobile messaging communications. Meteor-burst communication [9] was reported to be a viable means of providing communications services after a nuclear attack. Following the advent of satellite communications in the 1960s, there was less interest in post-attack communications by meteor-burst. However, the concept has become popular again since anti-satellite weapons were developed.

The meteor-burst technique (Figure 6) relies on bouncing VHF signals off ion trails ("meteor scatter") left by billions of dust-sized meteors between 85 km and 115 km above the earth's surface. Each meteor trail lasts from a fraction of a second to several seconds. To provide coverage to the entire U.S.A. continent, Transtrack's system [10,11] consists of five base stations which are connected to a network control centre via phone lines. Each base station can monitor several thousand vehicles within a 800-to-1100-km radius. In operation, the base station constantly transmits probe signals (43.92 MHz). Meteor trails in the atmosphere reflect the probe signals and illuminate foot prints (each foot print is approximately 50 km long by 25 km wide) on the ground. Any truck mobile unit within the illuminated area will receive the probe signal and know that it has a path to the base station, and respond with its own short burst signal (44 MHz).

Each meteor trail usually lasts long enough to transmit vehicle tracking data (as many as 32 characters). For longer messages, Transtrack must use a sequence of meteor trails and piece the resulting signals together at its network control centre and at the mobile unit. The small foot prints and short durations permit the system to monitor thousands of vehicles. The average waiting time for communications paths is estimated at less than 10 minutes. In other words, the system averages about 10

connections per hour with trucks that drive normal working routes. Leaseway Transportation collaborated with Transtrack in developing and testing the service. North American Van Lines will equip its tractor-trailers in high value shipments. The U.S. FCC has granted Transtrack a full duplex licence for commercial operation to serve up to 64 000 mobile units.

Another company utilizing the meteor-burst technique is Pegasus Message Corporation. Pegasus has an experimental licence from the U.S. FCC to operate its meteor-burst tracking system and may have a nationwide system in the near future. The meteor-burst technique is attractive because transmission is not dependent on satellites in potentially vulnerable orbits. However, the timing of a transmission burst is unpredictable since it depends on random events in nature.

Developments in Europe, Japan and Australia

Development of this technology in Europe and elsewhere in the world can be best described by INMARSAT's efforts. London-based INMARSAT (the International Maritime Satellite Consortium) is an international organization comprised of 55 member countries (Canada is one of them) and since 1982 has operated a global network of L-band satellites. INMARSAT was originally established to provide mobile communications and radio determination services to ships and aircraft throughout the world. With the recent amendments to its convention, it is in a position to service the needs of the land mobile users throughout the world. The INMARSAT Standard-C System is its first entry into land mobile communications.

Standard-C [12] is a smaller, lower-cost version of the Standard-A terminal now used by commercial ships. Standard-C can send and receive via a small omni-directional antenna. It exchanges data between mobiles and fixed earth stations at a data rate of 600 bits per second. Standard-C capabilities include two-way store and forward messaging, a short burst transmission mode for position and data reporting, polling and an enhanced group call facility. Position reporting is achieved by interfacing the Standard-C to a navigation device chosen by the user. To promote its Standard-C applications, INMARSAT has conducted a series of land-mobile satellite communications tests and demonstrations in Canada (in conjunction with TMI), the U.S.A., the USSR [13] and France [14]. A Standard-C equipped mobile van was used in the testing to send and receive messages between moving vehicles and INMARSAT headquarters in London, England.

The first of four new INMARSAT second-generation satellites are scheduled for launching at the end of 1989 to offer the land mobile user a greater range of services in the 1990s. INMARSAT has also investigated the feasibility of using its third generation geostationary satellites to transmit GPS look-alike signals to enhance the satellite navigation capability.

In 1988, a new European company, called Locstar [15, 16], was formed by Geostar of the U.S.A., CNES, the French space agency, three large European telecommunications operators – STET in Italy, Telefonica of Spain, and the France Telecom group – and other industrial groups in 1988. Locstar plans to initiate a Geostar-compatible service in Europe by 1991. After that, Locstar will extend the coverage to Africa, the Mediterranean and the Middle East.

Japan has performed aeronautical and maritime mobile satellite service field tests using the ETS-V satellite. Sony Corporation is one of the manufacturers of Geostar's radio determination satellite system and a Japanese trading company, C. Itoh & Co. Ltd., has invested in the Canadian mobile satellite company, TMI, as a minority shareholder and silent partner. Australia's national satellite company, Aussat Pty Ltd., is also participating in the ETS-V experiments.

Meanwhile, representatives of Telesat Mobile Inc., AMSC, Aussat and INMARSAT have formed an Ad Hoc Committee of Mobile Satellite Service (MSS) Operators as a forum to exchange information on MSS system planning and to facilitate the process of formulating common functional specifications [17] for mobile terminals. It is believed that the cooperation between TMI and AMSC will give them an edge in the North American market.

CONCLUSIONS

On a very broad scale, investments in mobile satellite technology for transportation industry applications are booming and the worldwide WAVM market amounts to billions of dollars. Nevertheless, there is no question that the competition in the transportation industry and in the WAVM technology and market will be very intense in the next few years. Ontario's public and private sectors have made taken steps to secure a strong foothold in this emerging technology and market. Society as a whole will be the eventual winner in this competition.

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Figure 1/ Wide Area Vehicle Monitoring System Concept

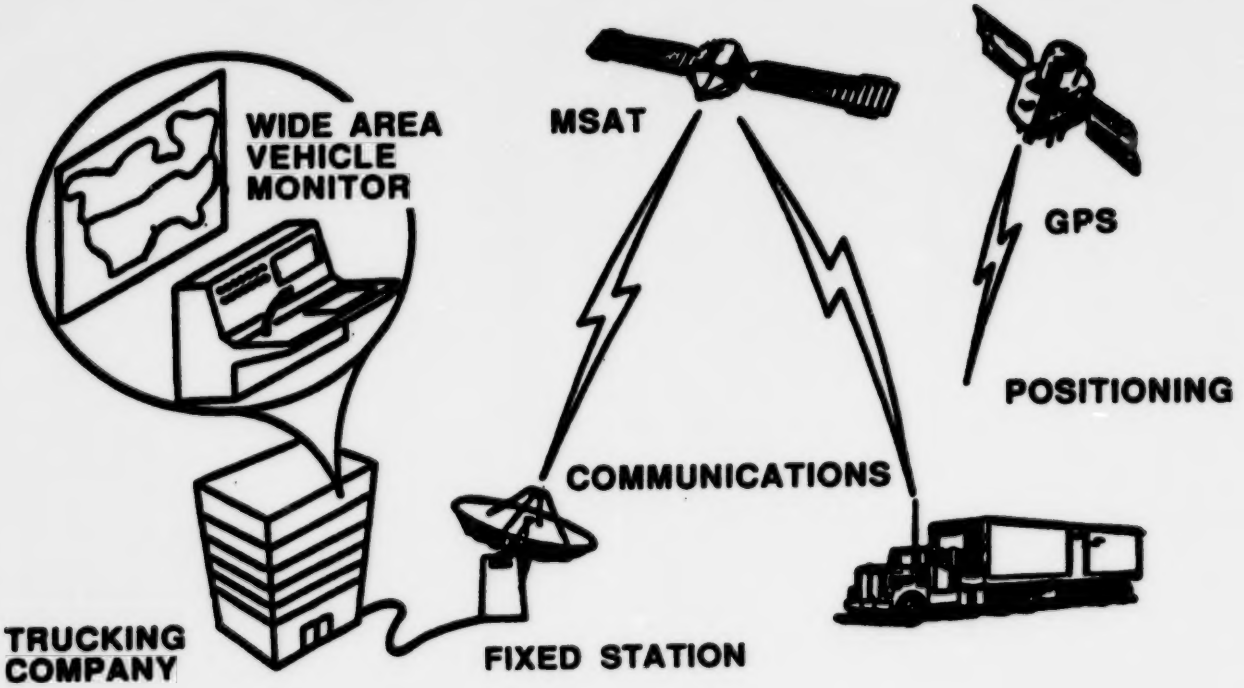
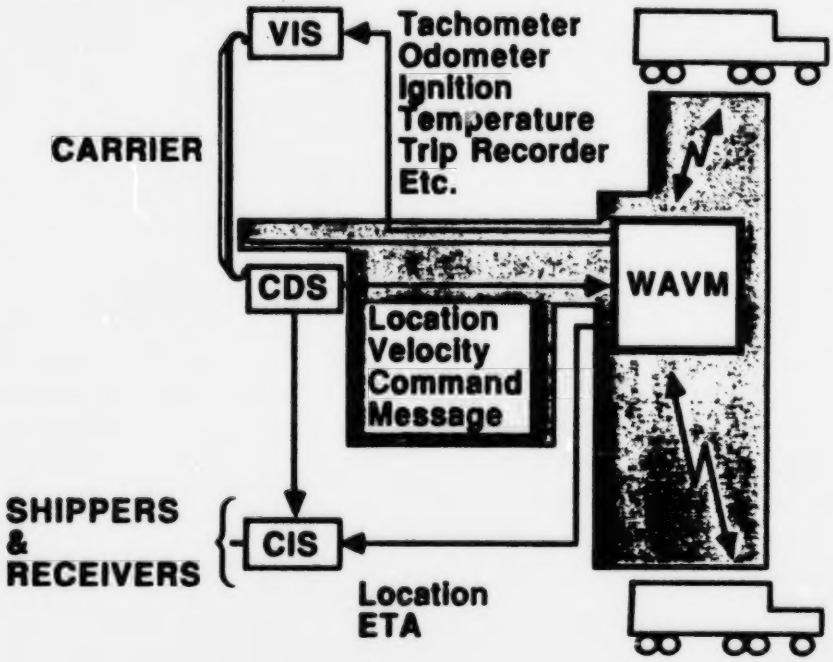


**Figure 2/ WAVM System -
An Important Missing Link**



CDS – COMPUTER DISPATCH SYSTEM
CIS – CUSTOMER INFORMATION SYSTEM
VIS – VEHICLE INFORMATION SYSTEM

Figure 3/ Interim Mobile Satellite Fleet Management System Concept

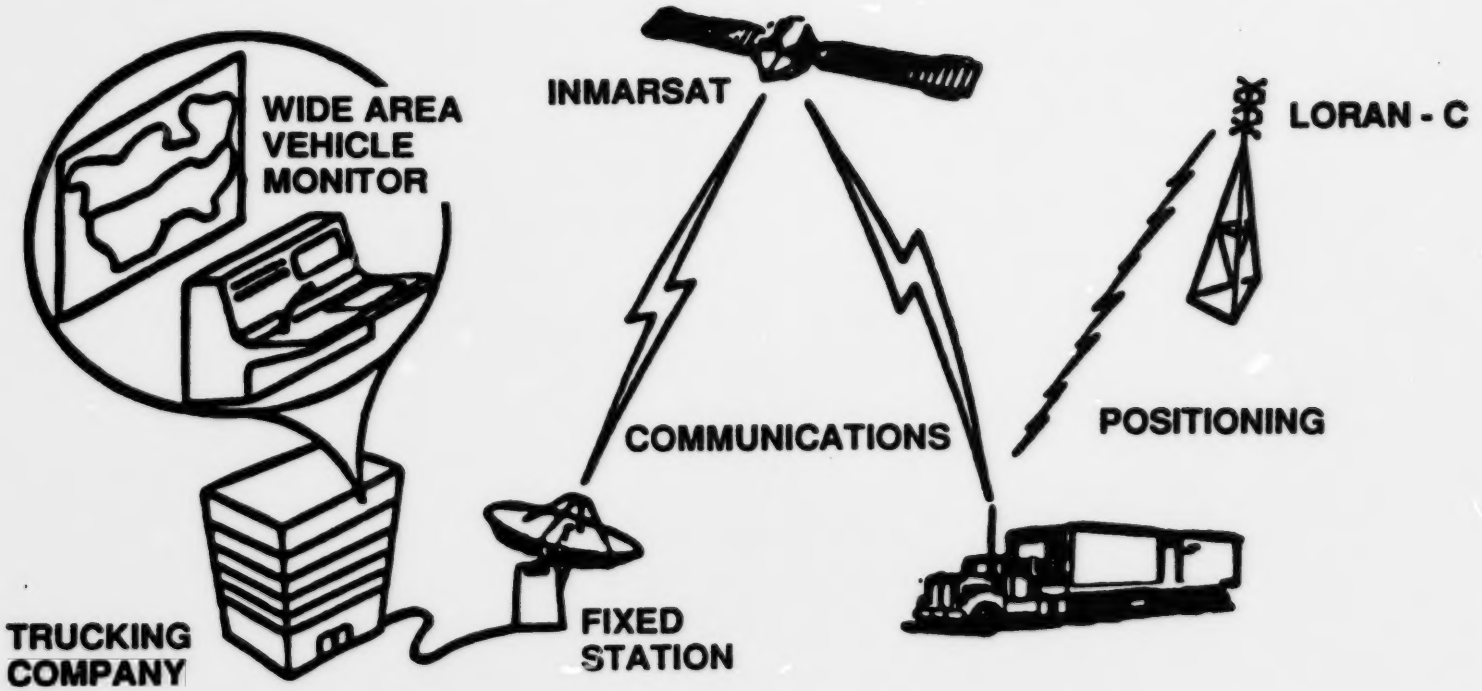


Figure 4/ WAVM North America Coverage

Figure 5/ Satellite Links of the Mobile Satellite Fleet Management System

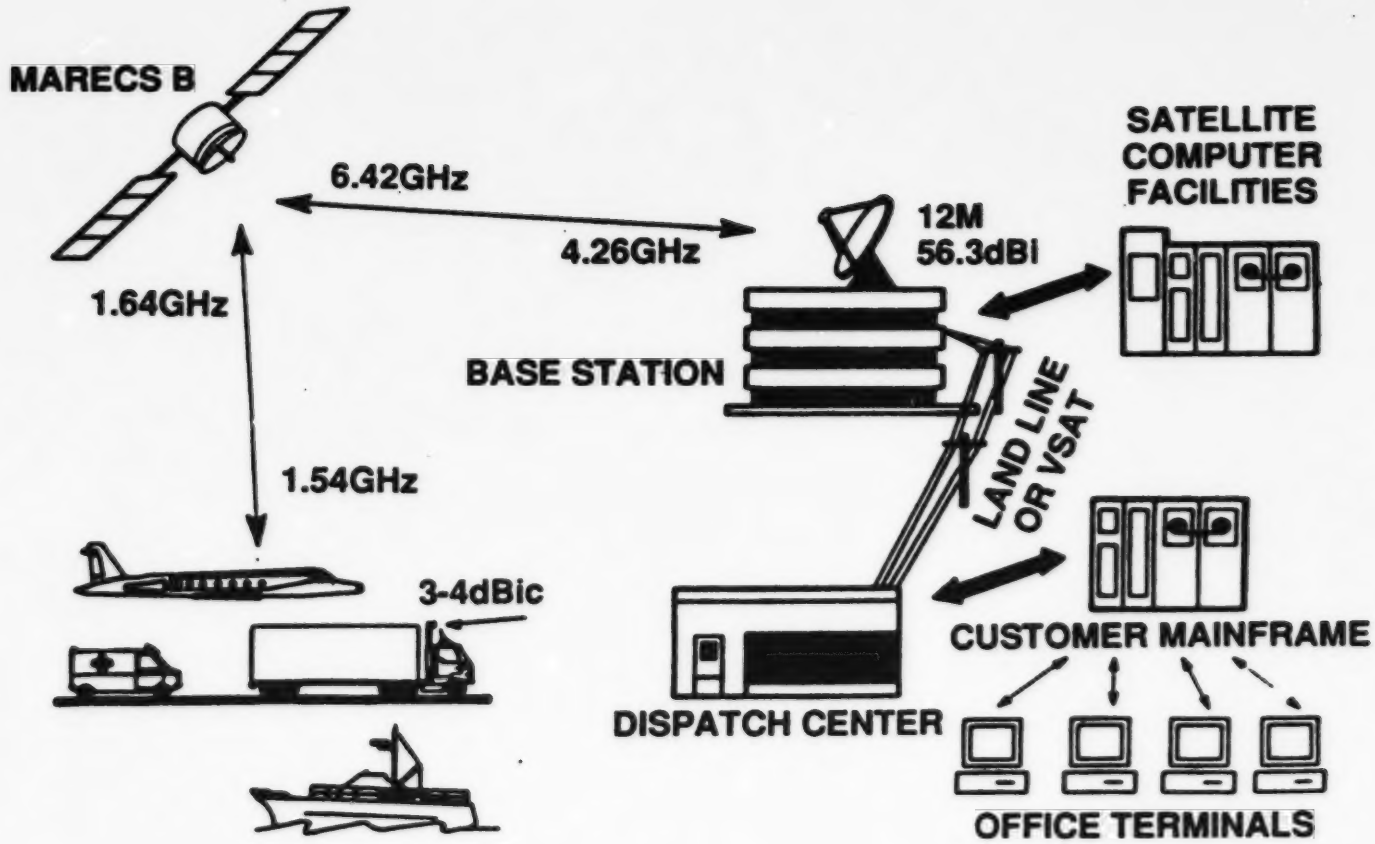


Figure 6/ Meteor-Burst Communications